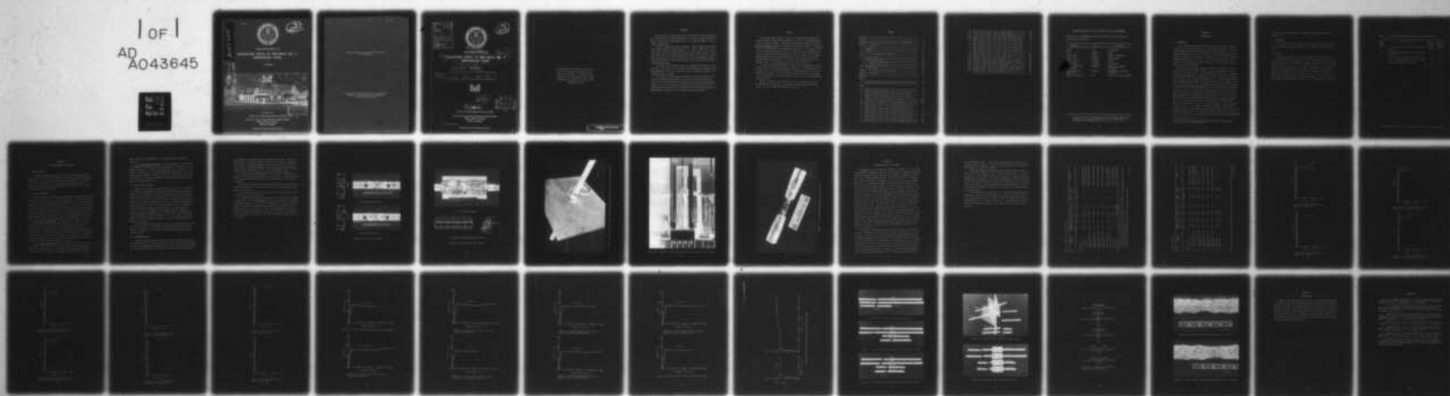
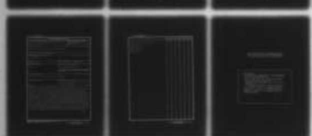
AD-A043 645 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 11/6
EVALUATION TESTS OF BEN-WELD NUMBER 11 REINFORCING STEEL.(U)
SEP 73 J R HOSSLEY
UNCLASSIFIED WES-M-P-N-73-5 NL

1 OF 1
AD A043645





END
DATE FILMED
9-77
DDC

2

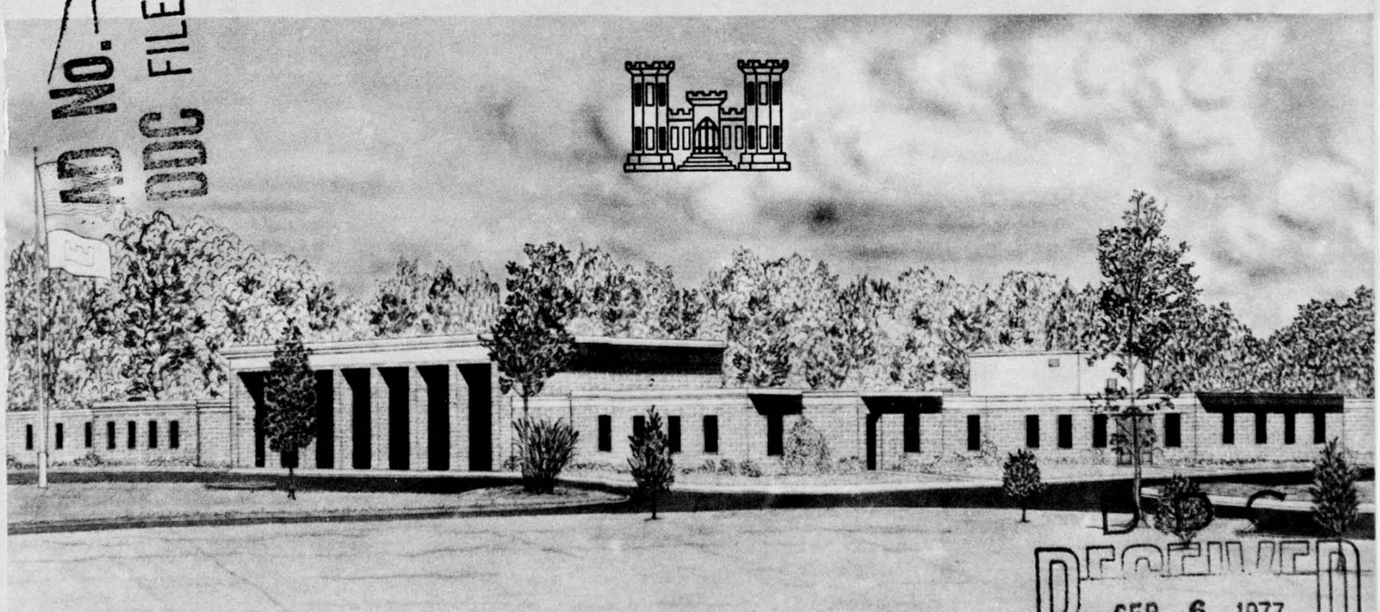
B.S.

MISCELLANEOUS PAPER N-73-5

EVALUATION TESTS OF BEN-WELD NO. 11 REINFORCING STEEL

by

J. R. Hossley



September 1973

Sponsored by U. S. Army Engineer Division, Huntsville

Conducted by U. S. Army Engineer Waterways Experiment Station
Weapons Effects Laboratory
Vicksburg, Mississippi

2

14 WES-M-P

MISCELLANEOUS PAPER N-73-5

Number

6

EVALUATION TESTS OF BEN-WELD ~~NO.~~ 11 REINFORCING STEEL.

by

10 James ~~J.~~ R. Hossley

9 Final rept. Jun-Dec 72,

12 41p.

11 Sep[redacted]r 1973

Sponsored by U. S. Army Engineer Division, Huntsville

Conducted by U. S. Army Engineer Waterways Experiment Station
Weapons Effects Laboratory
Vicksburg, Mississippi

ARMY-MRC VICKSBURG, MISS.

038 100

mt

ABSTRACT

The objective of this study was to determine the tensile properties at fast load rates of welded Ben-Weld No. 11 concrete reinforcing steel bars. Ben-Weld is a trade name of the U. S. Steel Corporation, Pittsburgh, Pennsylvania.

Nineteen tension tests were conducted. Twelve samples were spliced using three different welding methods; i.e., direct single-vee groove weld, direct double-vee groove weld, and indirect angle splice. Four of the sample bars were passed through and welded to a 1/4-inch-thick steel plate to simulate the rebar penetrations of the electromagnetic pulse (EMP) shields used in the Perimeter Acquisition Radar Building (PARB) of the SAFEGUARD System.

All samples were tested at static and dynamic (intermediate) loading rates. The time to reach yield at the intermediate loading rate was approximately 0.10 second. Transient load and strain measurements were recorded during the tests.

The results of these tests showed that a welded Ben-Weld bar will exceed the minimum requirements for tensile and yield strengths for Grade 60 bars as stipulated by the American Society for Testing and Materials. The test results also indicated that welding does not seriously affect the ductility of the material and that final elongations of approximately 20 percent can be expected from welded rebars.

PREFACE

This study was conducted at the U. S. Army Engineer Waterways Experiment Station (WES) and was sponsored by the U. S. Army Engineer Division, Huntsville (HND). The work was accomplished during the period June to December 1972 under the general supervision of Mr. W. J. Flathau, Chief of the Weapons Effects Laboratory, WES. Mr. J. T. Ballard, Chief of the Structures Division, and Mr. T. E. Kennedy of the Structures Division coordinated the testing program. Mr. F. P. Hanes of the Design and Development Branch, Instrumentation Services Division, provided technical advice and guidance. This report was prepared by Mr. J. R. Hossley, Chief of the Operations Group, Structures Division.

It would not have been possible to conduct the experimental portion of this study without the assistance of Messrs. A. H. McMillen and H. L. Worrell of the U. S. Steel Corporation in the procurement of the reinforcing steel samples. This represents a special effort on their part since the Ben-Weld steel was not being rolled in No. 11 size at the time of these tests.

BG E. D. Peixotto, CE, and COL G. H. Hilt, CE, were Directors of the WES during the conduct of this study and the preparation of this report. Mr. F. R. Brown was Technical Director.

CONTENTS

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
square inches	6.4516	square centimeters
square feet	0.092903	square meters
pounds (force)	4.448222	newtons
kips (force)	4.448222	kilonewtons
pounds (force) per square inch	6.894757	newtons per square centimeter
kips (force) per square inch	6.894757	kilonewtons per square centimeter
Fahrenheit degrees	5/9	Celsius or Kelvin degrees[a]

[a] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

In the design and construction of shear wall structures to resist the effects of nuclear weapons, it is frequently necessary to shield internal equipment from electromagnetic pulse (EMP) radiation. This is usually accomplished by using a continuous shield of heavy-gage steel on either the interior or the exterior surfaces of the structure. In some SAFEGUARD structures, this shield is on the interior surfaces. The points at which reinforcing steel penetrates this shield plate must be sealed in a positive manner.

Reinforcing bars larger than No. 11 should be spliced by some mechanical means or by welding. Welding onto or butt-welding Grade 75 rebars can seriously reduce the final elongation (from 10 to 1 percent) of some reinforcing steels. Embrittlement of No. 11 Grade 75 rebars has been observed in two studies performed at the U. S. Army Engineer Waterways Experiment Station (WES) (References 1 and 2). This embrittlement of the reinforcing steel in some cases may be tolerated in design considerations because minimum specifications for yield and tensile strength can be met. However, a more severe problem could arise because an embrittled rebar would be subject to cracking due to the stress of handling, placing, and vibrating during construction. A new weldable type (Ben-Weld) controlled-chemistry reinforcing steel is being produced by the U. S. Steel Corporation that will meet ASTM A 615 (Reference 3) Grade 60 specifications. The U. S. Steel Corporation supplied WES with 140 feet[1] of No. 11 size steel for evaluation testing. These large-diameter rebars are designed with ductile properties for use in high-rise buildings, nuclear plants, structures to resist seismic forces, and other critical applications. Chief advantages of this steel are simplified lower

---

[1] A table of factors for converting British units of measurement to metric units is presented on page 8.

cost welding procedures and a more compact design through more acute bending.

1.2 OBJECTIVE

The objective of this study was to determine the tensile properties at fast load rates of welded Ben-Weld No. 11 concrete reinforcing steel bars.

1.3 SCOPE

Nineteen test samples were constructed from the Ben-Weld material and tested as indicated in Table 1.1. Three samples were tested in the as-rolled state. Four samples were prepared by welding a 1/4-inch-thick, 18-inch-square steel plate onto a rebar to represent the structural penetration of an EMP shield. The remaining 12 samples were prepared as direct and indirect butt splices using four 45-degree, single-vee groove welds, four double-vee groove welds, and four flare-bevel groove weld butt splices using a single angle splicing member. Dynamic tests were conducted at an intermediate strain rate of approximately 0.05 in/in/sec.

TABLE 1.1 TEST PLAN FOR EVALUATION OF WELDABLE REINFORCING BARS

No. of Bars Tested	Condition of Bar	No. of Static Tests	No. of Dynamic Tests
3	As-rolled	2	1
4	Penetrating and welded to 1/4-inch-thick steel plate	2	2
4	Spliced using double-vee groove butt weld	2	2
4	Spliced using single-vee groove butt weld	2	2
4	Spliced using angle splice weld	2	2
	TOTAL	10	9

CHAPTER 2

TEST EQUIPMENT AND PROCEDURES

2.1 TESTING DEVICE

All dynamic tests were performed in the WES 200-kip-capacity dynamic loader. The theory and operation of this machine are described in Reference 2. In all tests, the machine was programmed for a loading rate that would produce a time to yield load of about 0.10 second. A special pour-type gripping system designed at WES was used to connect the rebar samples to the loader.

2.2 SAMPLE PREPARATION

The Ben-Weld steel reinforcing bar samples were cut from the 20-foot lengths furnished by the U. S. Steel Corporation. The Ben-Weld steel is rolled from a controlled-chemistry melt and meets or exceeds ASTM A 615 (Reference 3) Grade 60 strength specifications. Each end of the dynamic samples was threaded for a 1-3/8-inch-diameter, National Fine retaining nut. All bars were manually shielded-arc-welded using low-hydrogen type electrodes of AWS A5.5 Class E90xx-D1, G or M (Reference 4) and a minimum interpass temperature of 60 F. The 5/32-inch-diameter welding electrodes were manufactured by Atom-ARC and were identified as 90 18 CM.

2.2.1 Direct Butt Splices. The samples to be welded using the single-vee groove weld and the double-vee groove weld were saw-cut as shown in Figure 2.1 to conform to recommendations in Reference 5 (AWS D12.1-61). Preheating was not necessary since the ambient temperature was 70 F. The unwelded bars were first positioned in a steel angle to maintain proper alinement during welding. Welding was accomplished by qualified welders with dc manual electric arc-welding units. A pretest view of these samples is shown in Figure 2.1.

2.2.2 Indirect Butt Splices. The flare-bevel groove weld was prepared using a 3-1/2- by 3-1/2- by 1/2-inch-thick, equal-leg splicing angle. The angle was made of low-carbon steel conforming to ASTM A 36 (Reference 6). Two 9/16-inch, fillet-type welds were used to attach

each rebar to the splicing angle. The splicing angle is shown in Figure 2.2.

2.2.3 Plate Penetration Bars. An 18-inch-square, 1/4-inch-thick steel (ASTM A 36, Reference 6) plate was welded to four test bars as shown in Figure 2.3. The weld was approximately 1/2 inch thick at the throat to insure that the 1-5/8-inch-diameter hole drilled in the steel plate would be plugged. The steel plates were welded to the bars and then machined to 4 inches in diameter to simplify handling of the samples to be tested dynamically.

2.3 DESCRIPTIONS OF TESTS

Nineteen tension tests were performed. Rebar tests at the dynamic load rate were performed in the WES 200-kip-capacity loader shown in Figure 2.4. The dynamically tested samples were fitted with grippers and pulled in tension in a manner similar to that described in Reference 2. To insure that the 4-inch stroke of the 200-kip loader would be adequate to stretch the samples to failure, the sample length between grips was held to 8 inches, as shown in Figure 2.5, for all samples to be tested dynamically except the angle splices. A gage length of 6 inches was used. Although the gage length normally recommended in ASTM specifications (Reference 3) is 8 inches, the 6-inch gage length meets the ASTM specification (Reference 7) of four times the nominal diameter of the bar. Gage marks were not used on the dynamically tested angle splice samples.

A 440,000-pound-capacity Baldwin Universal testing machine was used for the static tests. The vee-wedge type grips were used to grip the samples. A distance of 24 inches was maintained between the top and bottom grippers.

2.4 INSTRUMENTATION

During the dynamic tests, load was measured by a load cell that was an integral part of the connections on the lower end of each test sample. The load cell (dynamometer) had a maximum capacity of over 200,000 pounds and was carefully machined from 4130 steel. Four 120-ohm strain gages

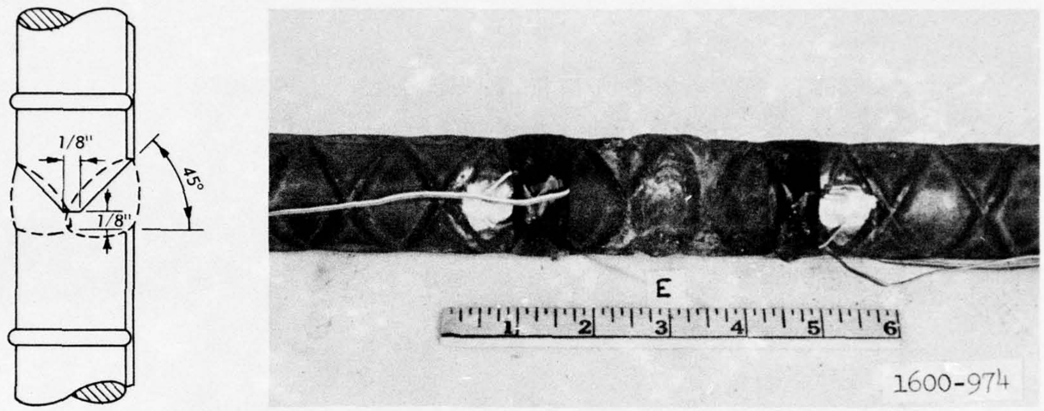
were mounted on the surface at the midheight of the cell. Two of the gages (mounted 180 degrees apart) were mounted to measure circumferential strain. The gage pairs were connected electrically to form two active arms of a wheatstone bridge, with two additional strain gages as opposite arms of the bridge; i.e., a four-arm bridge circuit.

All samples were instrumented with strain gages to determine the state of strain at various locations on the test bars. Strain levels up to and greater than yield strain were measured using 0.25-inch metal foil gages.

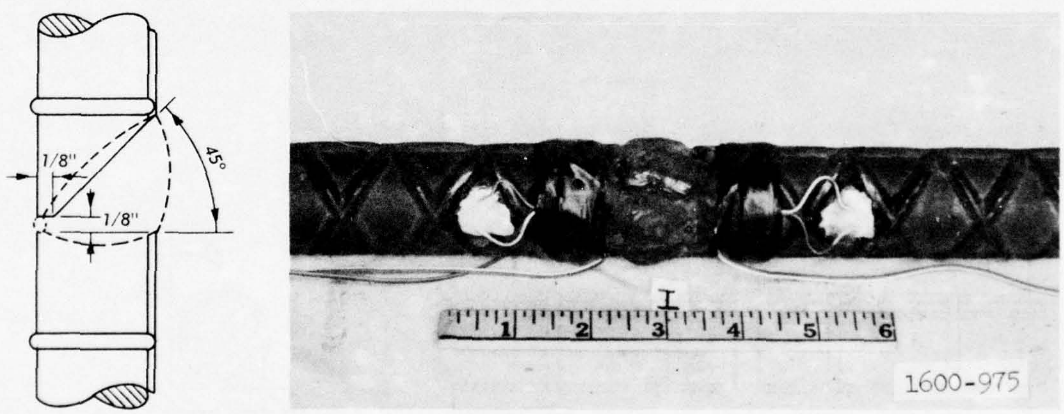
Two separate longitudinal strain measurements were made with gages located approximately 3 inches below the weld joints and diametrically opposite each other.

In the case of the angle splice bars, the strain gages were placed 1 inch from the end of the angle.

One high-elongation-type strain gage was also placed longitudinally on each sample. The high-elongation gages are advertised to be capable of measuring strain up to 10 percent. Measurements of dynamic load and strain were recorded simultaneously on magnetic-tape machines having a frequency response of 20,000 Hz. Static load measurements were taken directly from the load-indicating dial on the Universal testing machine. Strain measurements were made on the statically tested samples with an X-Y plotter.



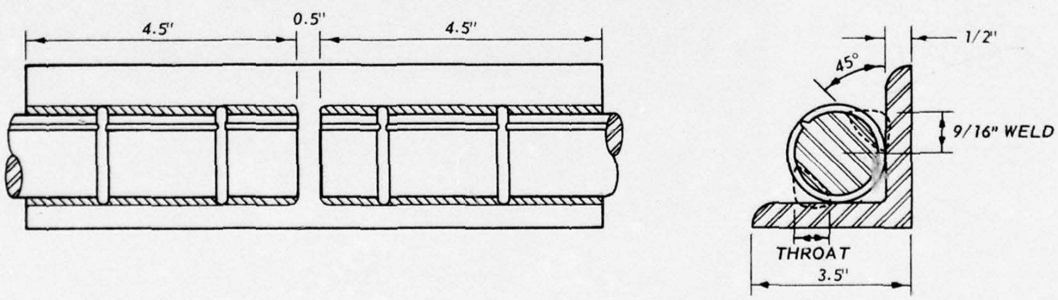
a. Single-vee groove weld.



b. Double-vee groove weld.

Figure 2.1 Direct butt splices.

a. Bar welded to angle.



b. Schematic of flare-bevel groove weld.

Figure 2.2 Indirect butt angle splice.

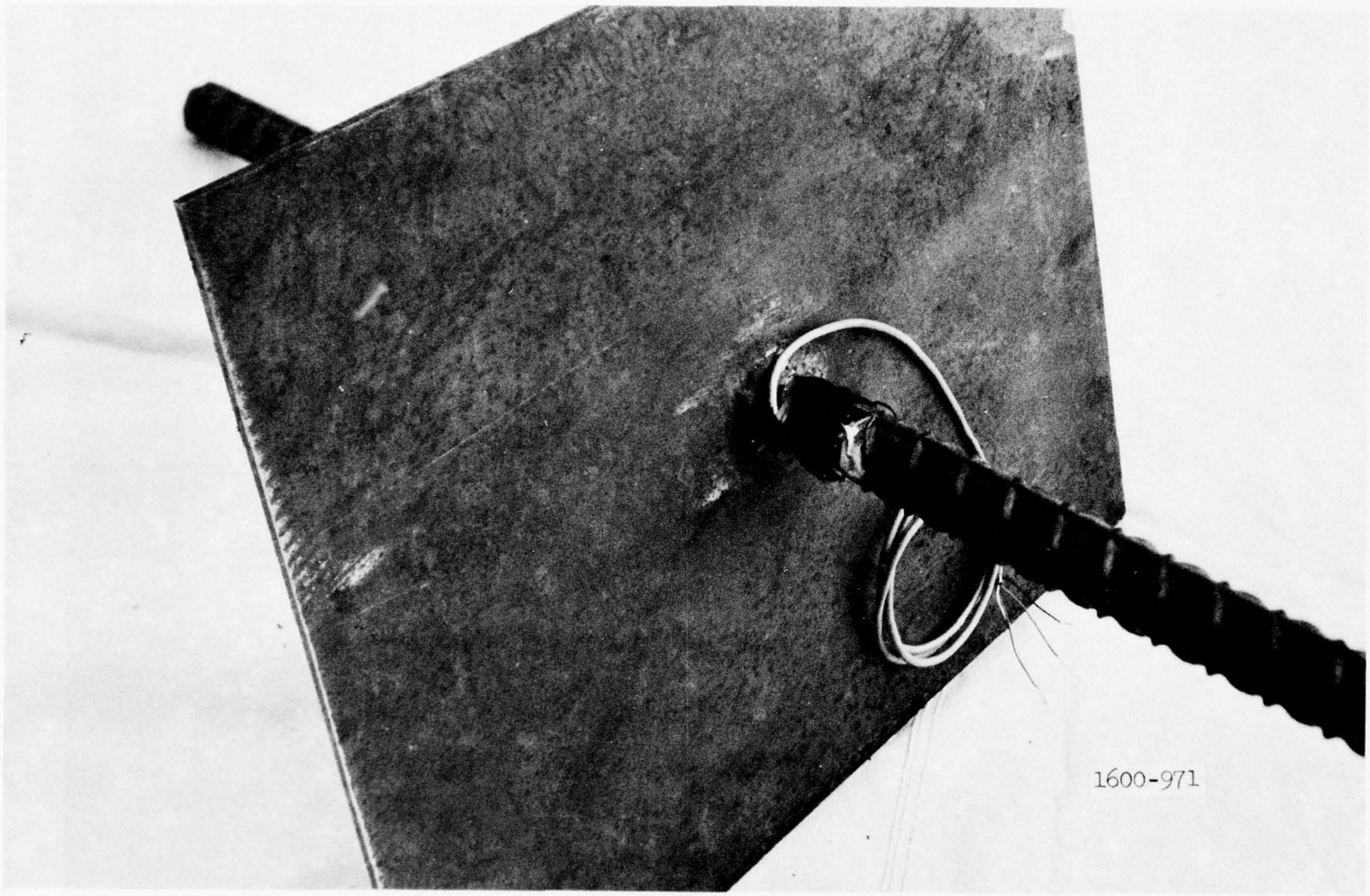


Figure 2.3 Pretest view of sample bar penetrating and welded to 1/4-inch-thick steel plate.

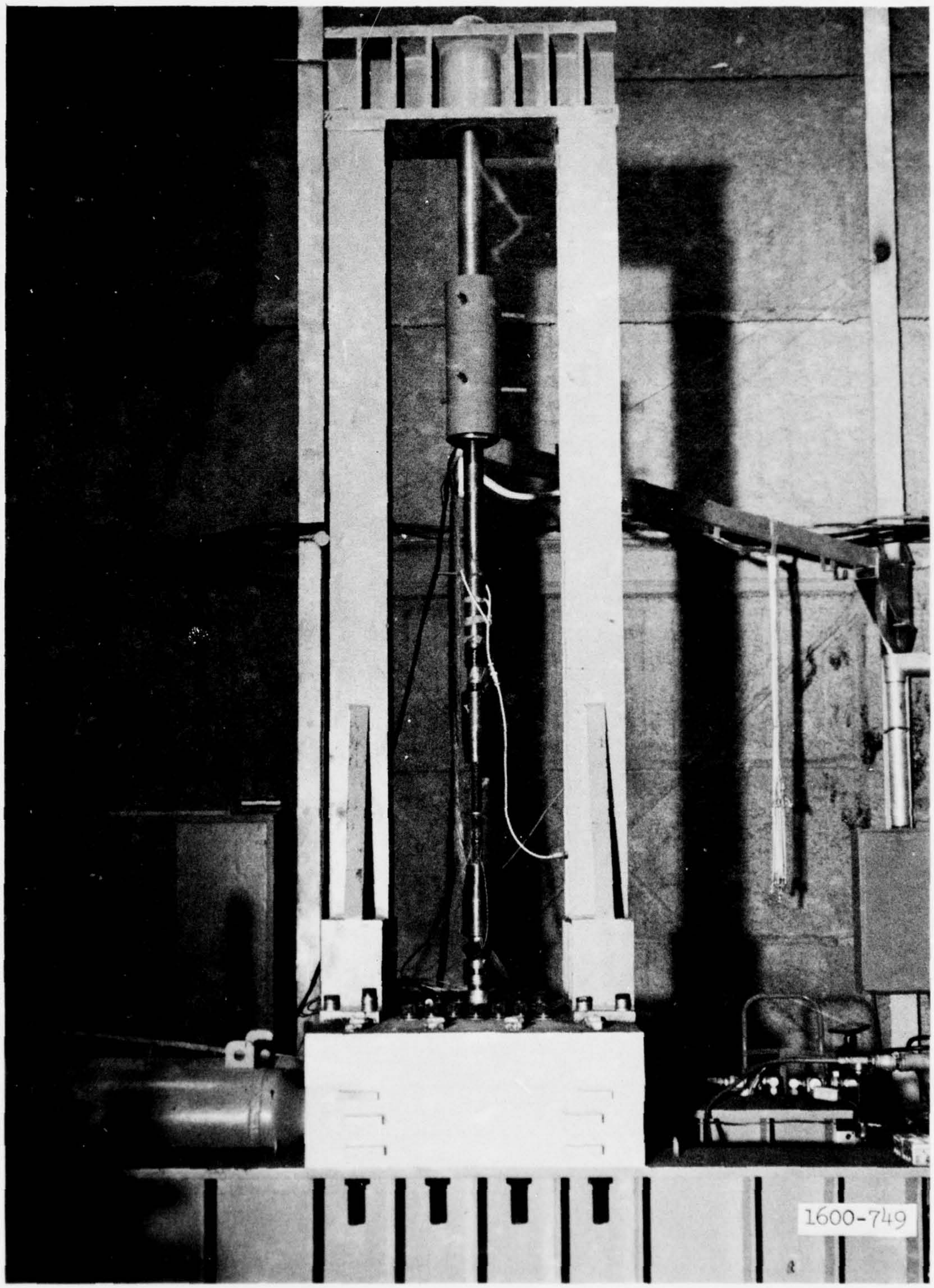


Figure 2.4 Sample in 200-kip-capacity loader ready for tension testing.

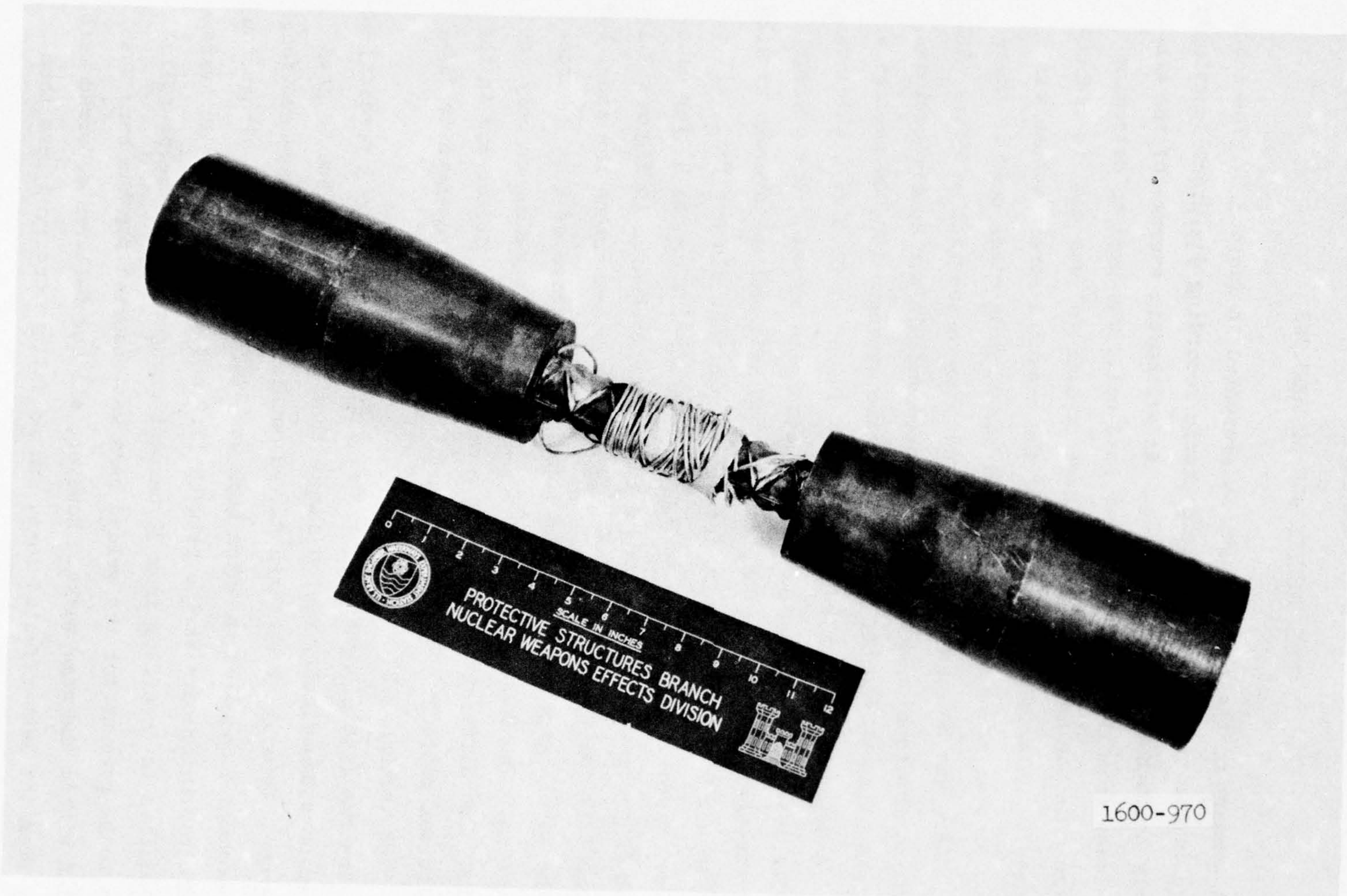


Figure 2.5 Bar with poured grippers ready for testing.

CHAPTER 3

TEST RESULTS AND DISCUSSIONS

A summary of the test results is presented in Table 3.1. The loading equipment, transducers, and electronic recording equipment functioned properly throughout the test series. An arithmetic average of the measured loads from the upper and lower load cells was used to determine the stress in the bars. A nominal area of 1.56 in^2 was used in computing stress. An arithmetic average of the measured strain values was used to plot stress-strain curves. At the loading rates used in these tests, there was no appreciable influence due to inertial effects. All but one of the tension-tested samples exceeded minimum specifications for yield strength (60,000 psi) and tensile strength (90,000 psi) as set forth in Reference 3. As-rolled Sample 1 failed at 88.8 ksi, which was slightly less than the minimum allowable tensile stress. The average yield strength for all the samples was 76.5 ksi, and the average tensile strength was 94.1 ksi. Except for one sample that did not fail, all samples exceeded the minimum ASTM specification (Reference 3) for elongation (7 percent). Stress-strain curves are presented in Figures 3.1 through 3.19 for the samples. The epoxy glue bond between the steel bar and the strain gage began to deteriorate in the range of 2 to 3 percent elongation. The bond held for up to 10 percent elongation on only one sample. Two different epoxy glues were used, but no difference in the results was noticed. Posttest views of the samples are shown in Figures 3.20 through 3.24.

The smallest elongation recorded during the tests (5.3 percent) occurred on a dynamically tested sample that did not break due to grip slippage. Several of the bars failed outside the gage-marked section; the average elongation on these bars was 11.8 percent. The elongation of the remaining bars varied between 17.2 and 35.0 percent. An average degradation in ductility from 32 percent elongation for the as-rolled bars to 22 percent for the welded bars was observed for the bars that failed within the gage marks. However, all bar failures occurred well away from the heat-affected zone, and no failure occurred less than

3 inches from the welds. Three sets of gage marks were made on some statically tested samples. Figure 3.25 shows variations of elongation measurements for some of the samples.

All posttest samples indicated a great amount of necking down at the failure section (Figure 3.26), which is characteristic of a ductile type failure. The average reduction of area for the samples tested was approximately 60 percent. An accurate measurement of reduction of area is difficult to make because of the deformation pattern on the full-size rebars. Reduction of area requirements are, although commonly used as an indication of material ductility, not called for in rebar specifications (Reference 3).

Of the steel bars received from U. S. Steel, some showed signs of a longitudinal flaw. The test samples were selected from material that did not visually show a flaw. After testing, the flaw became evident on some samples, as can be seen in Figure 3.27. The flaw did not seem to affect the mechanism of failure or the mechanical properties of the material.

TABLE 3.1 SUMMARY OF TENSION TEST RESULTS

Test No.	Sample Condition	Maximum Stress[a] σ_m	Yield Stress[b] σ_y	Yield Strain ϵ_y	Final Elongation[c]	Strain Rate ϵ	Time to Yield t_y	Remarks
		ksi	ksi	in/in	percent	in/in/sec	sec	
Static Tests:[d]								
1	As-rolled bar	88.8	66.0	0.0025	29.1	--	--	Ruptured inside gage marks
2	As-rolled bar	92.0	73.5	0.0026	15.3	--	--	Ruptured outside gage marks
3	Double-vee groove weld butt splice	91.4	69.8	0.0026	10.0	--	--	Ruptured outside gage marks
4	Double-vee groove weld butt splice	90.4	69.5	0.0026	10.8	--	--	Ruptured outside gage marks
5	Single-vee groove weld butt splice	91.4	68.0	0.0025	10.7	--	--	Ruptured outside gage marks
6	Single-vee groove weld butt splice	90.4	68.5	0.0027	10.2	--	--	Ruptured outside gage marks
7	Plate penetration bar	92.5	76.0	0.0024	27.7	--	--	Ruptured inside gage marks
8	Plate penetration bar	92.5	75.0	0.0026	20.8	--	--	Ruptured inside gage marks
9	Angle splice	92.0	76.0	0.0027	25.6	--	--	Ruptured inside gage marks
10	Angle splice	92.0	75.0	0.0026	28.8	--	--	Ruptured inside gage marks

(Continued)

[a] A nominal cross-sectional area of 1.56 in^2 was common to all bars.

[b] All bars showed a pronounced yield point (computed using 0.2 percent offset method presented in Reference 7).

[c] Elongation was measured over a 6-inch gage length.

[d] Static tests were performed at an average time to yield strength of 5 minutes.

TABLE 3.1 CONCLUDED

Test No.	Sample Condition	Maximum Stress[a] σ_m	Yield Stress[b] σ_y	Yield Strain ε_y	Final Elongation[c]	Strain Rate ε	Time to Yield t_y	Remarks
		ksi	ksi	in/in	percent	in/in/sec	sec	
Dynamic Tests:								
225	As-rolled bar	101.0	79.0	0.0030	35.0	0.053	0.068	Ruptured inside gage marks
226	Plate penetration bar	91.6	80.0	0.0025	17.2	0.033	0.098	Ruptured inside gage marks
227	Plate penetration bar	99.5	85.0	0.0032	14.0	0.052	0.066	Ruptured outside gage marks
228	Double-vee groove weld butt splice	93.0	80.0	0.0030	5.3	0.032	0.093	Bar did not break
229	Double-vee groove weld butt splice	95.0	80.0	0.0033	18.7	0.053	0.068	Ruptured inside gage marks
230	Single-vee groove weld butt splice	98.0	83.0	0.0030	20.0	0.054	0.061	Ruptured inside gage marks
231	Single-vee groove weld butt splice	98.5	83.0	0.0034	19.7	0.056	0.064	Ruptured inside gage marks
232	Angle splice	98.6	85.0	0.0034	--	0.053	0.065	--
233	Angle splice	98.6	83.0	0.0029	--	0.047	0.060	--

(2 of 2 sheets)

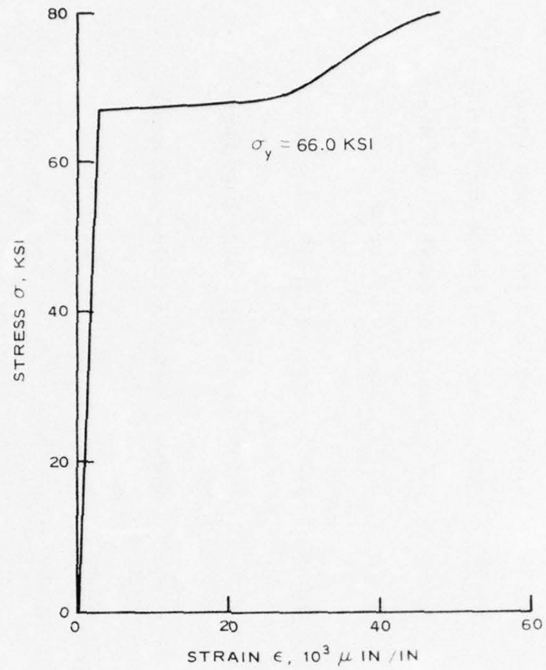


Figure 3.1 Stress versus strain, Test 1, as-rolled bar.

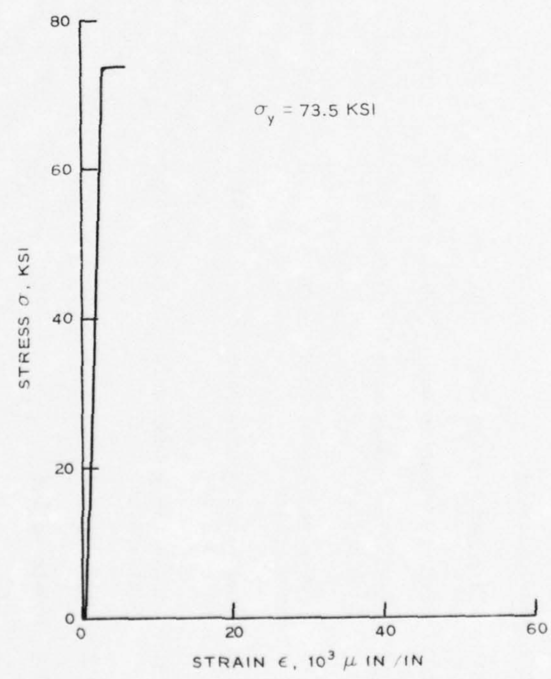


Figure 3.2 Stress versus strain, Test 2, as-rolled bar.

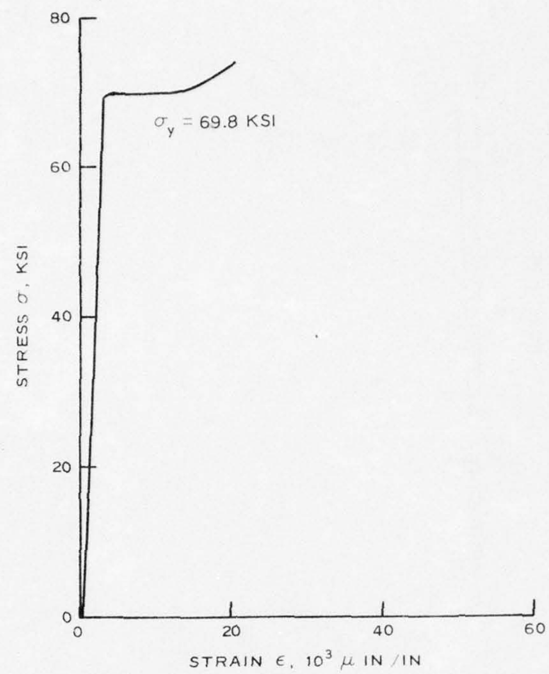


Figure 3.3 Stress versus strain, Test 3, double-vee groove weld butt splice.

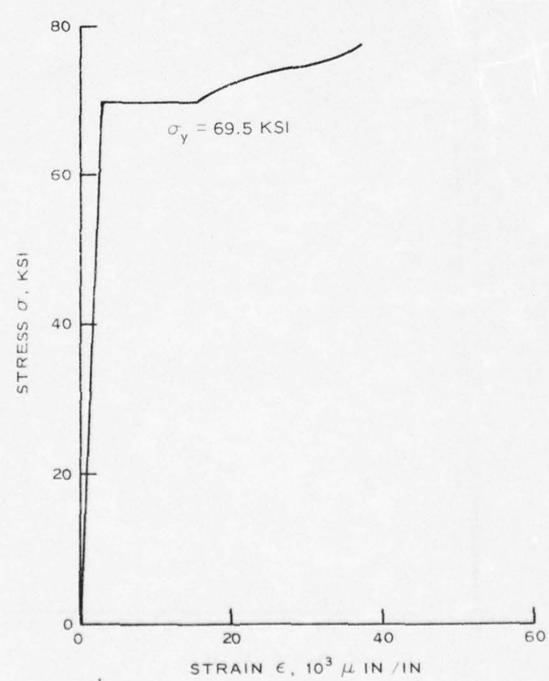


Figure 3.4 Stress versus strain, Test 4, double-vee groove weld butt splice.

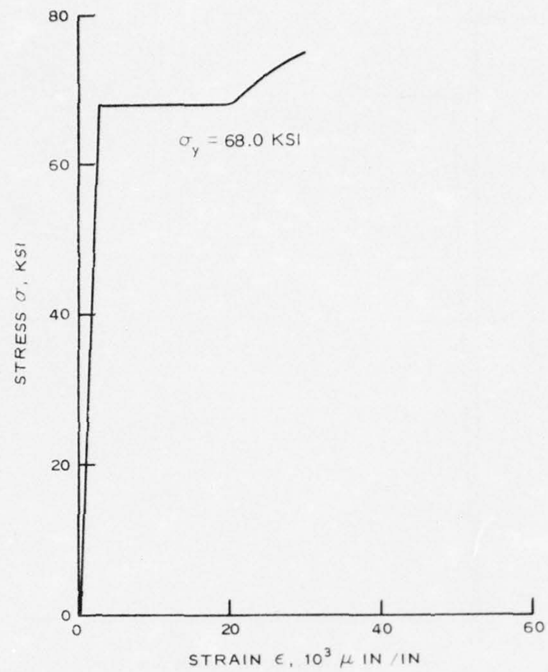


Figure 3.5 Stress versus strain, Test 5, single-vee groove weld butt splice.

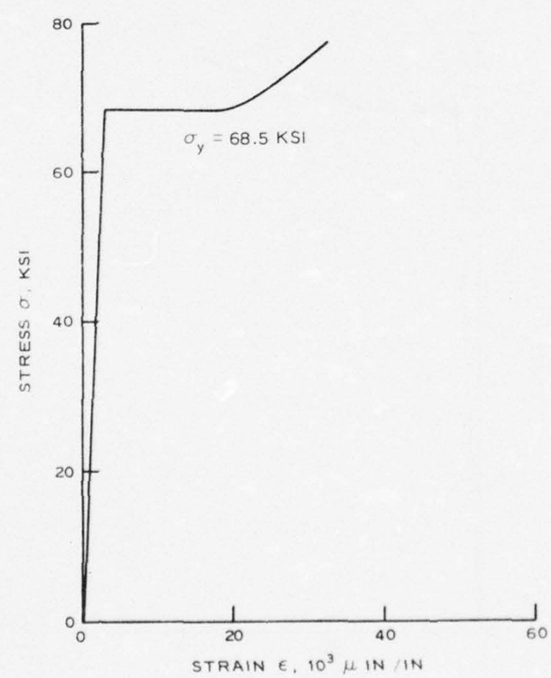


Figure 3.6 Stress versus strain, Test 6, single-vee groove weld butt splice.

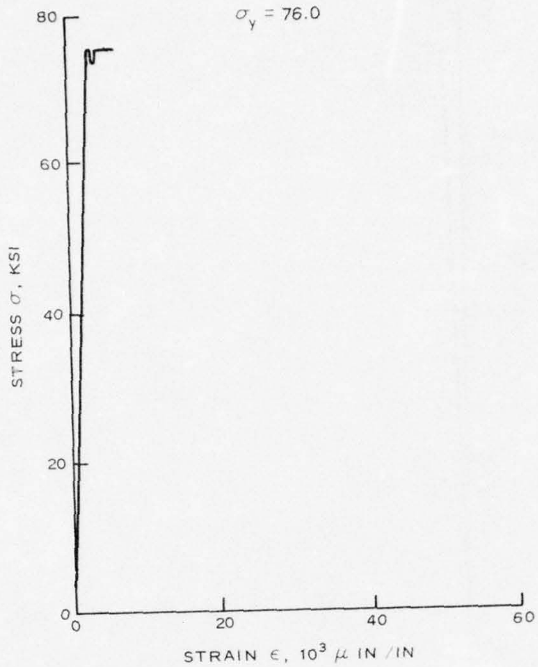


Figure 3.7 Stress versus strain, Test 7, plate penetration bar.

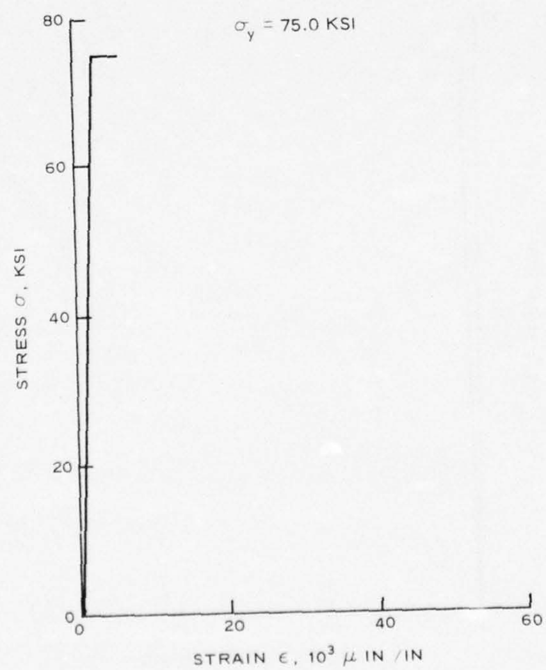


Figure 3.8 Stress versus strain, Test 8, plate penetration bar.

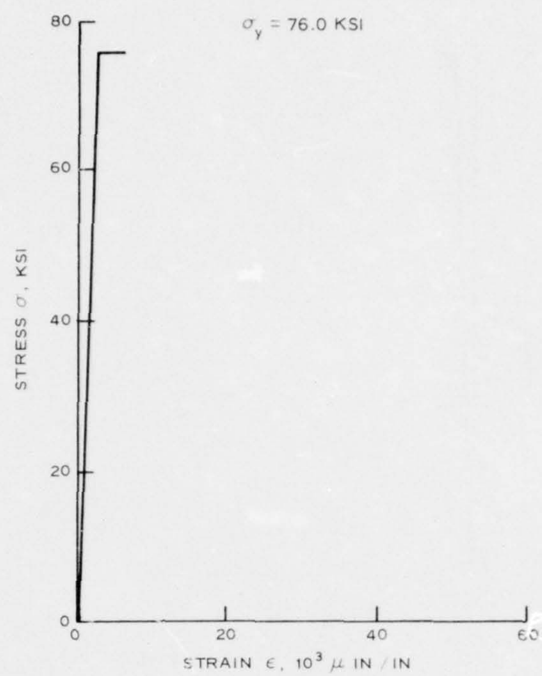


Figure 3.9 Stress versus strain, Test 9, angle splice.

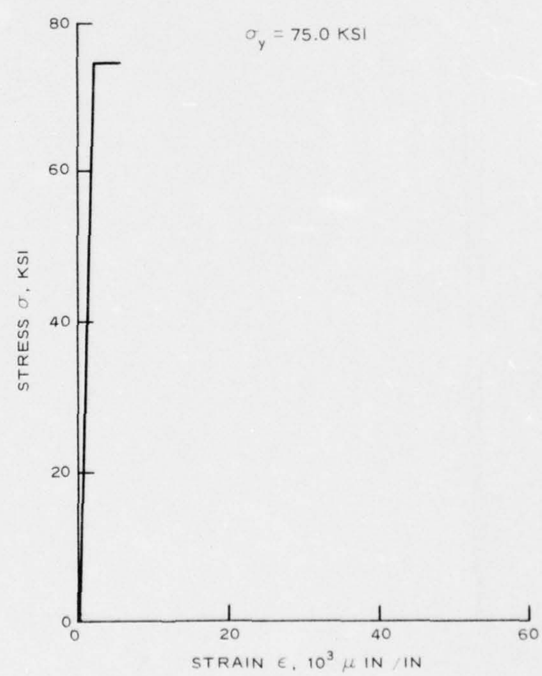


Figure 3.10 Stress versus strain, Test 10, angle splice.

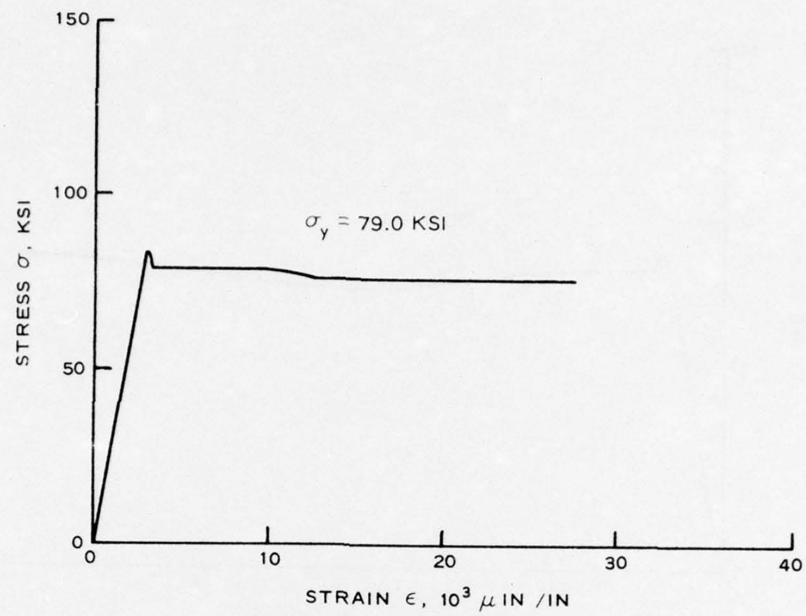


Figure 3.11 Stress versus strain, Test 225, as-rolled bar.

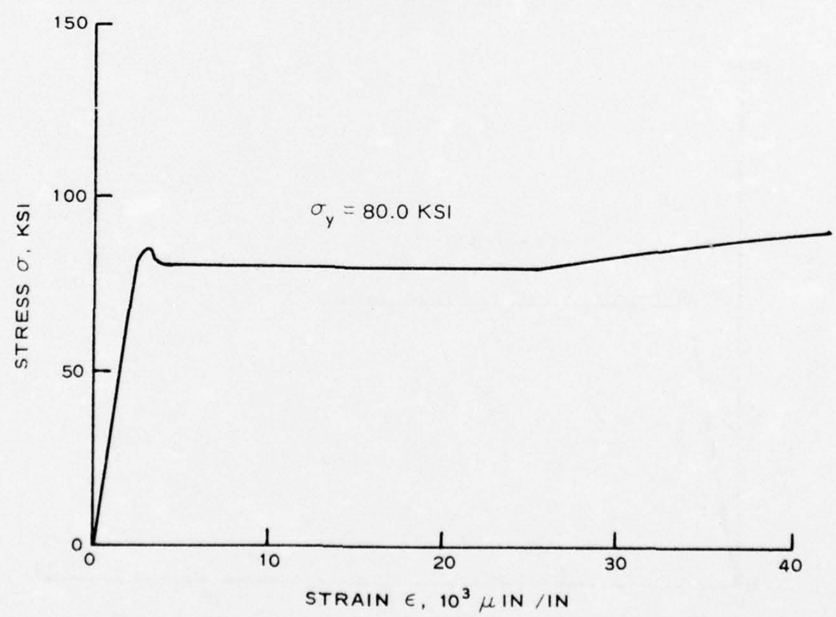


Figure 3.12 Stress versus strain, Test 226, plate penetration bar.

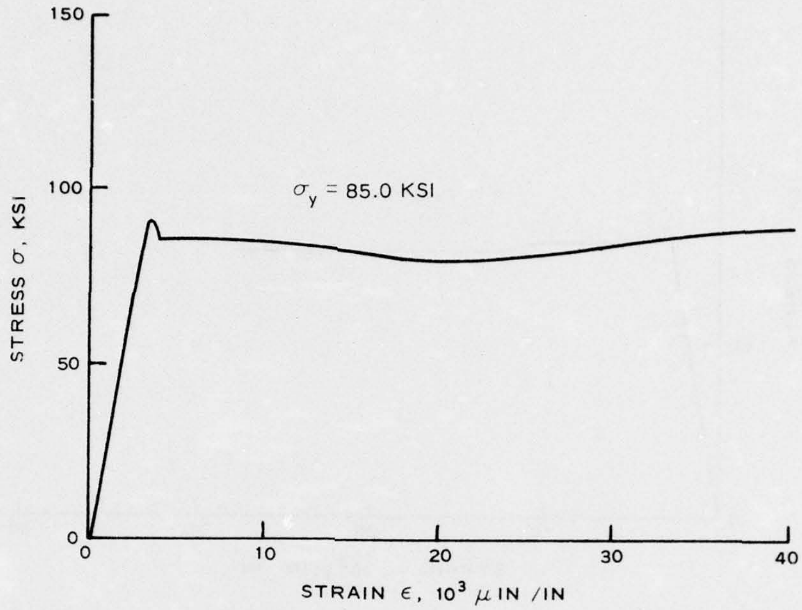


Figure 3.13 Stress versus strain, Test 227, plate penetration bar.

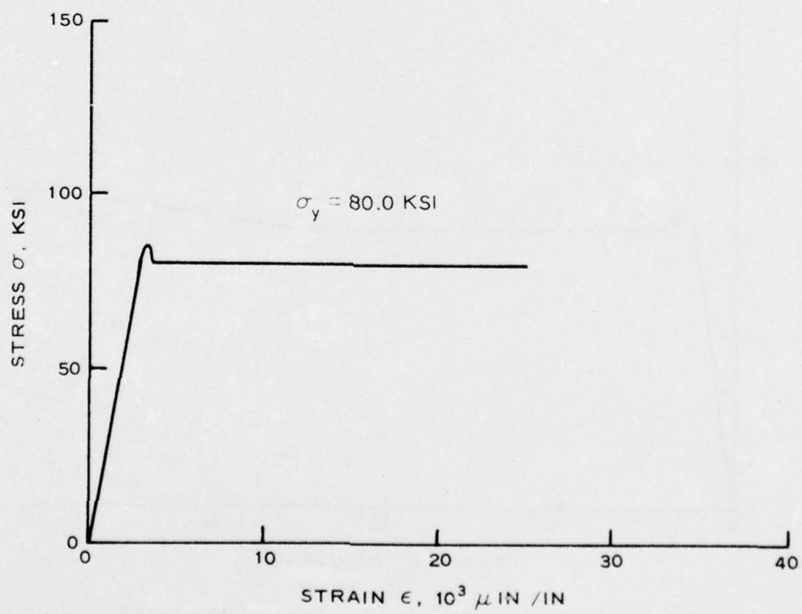


Figure 3.14 Stress versus strain, Test 228, double-vee groove weld butt splice.

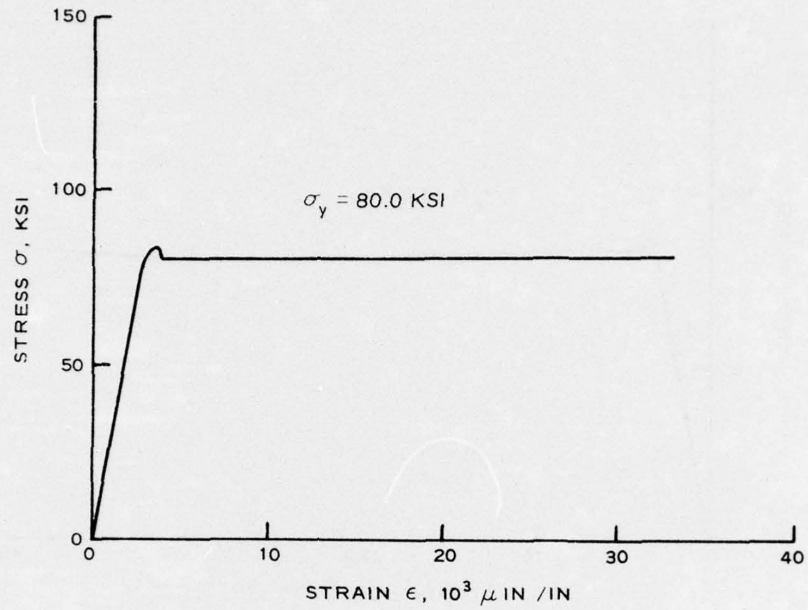


Figure 3.15 Stress versus strain, Test 229, double-vee groove weld butt splice.

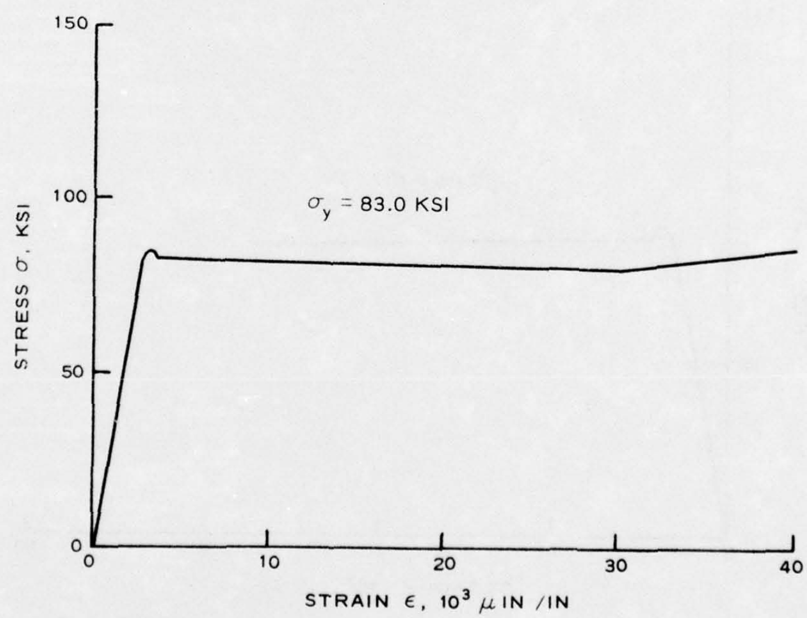


Figure 3.16 Stress versus strain, Test 230, single-vee groove weld butt splice.

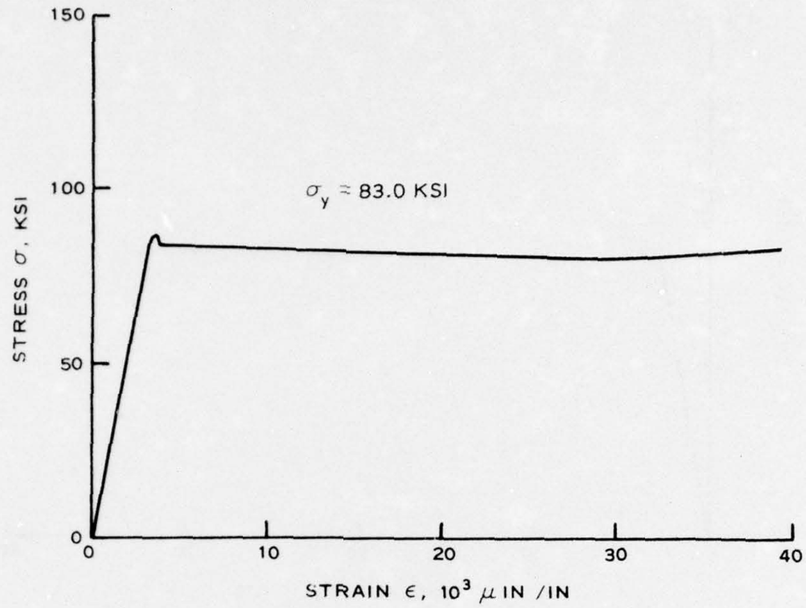


Figure 3.17 Stress versus strain, Test 231, single-vee groove weld butt splice.

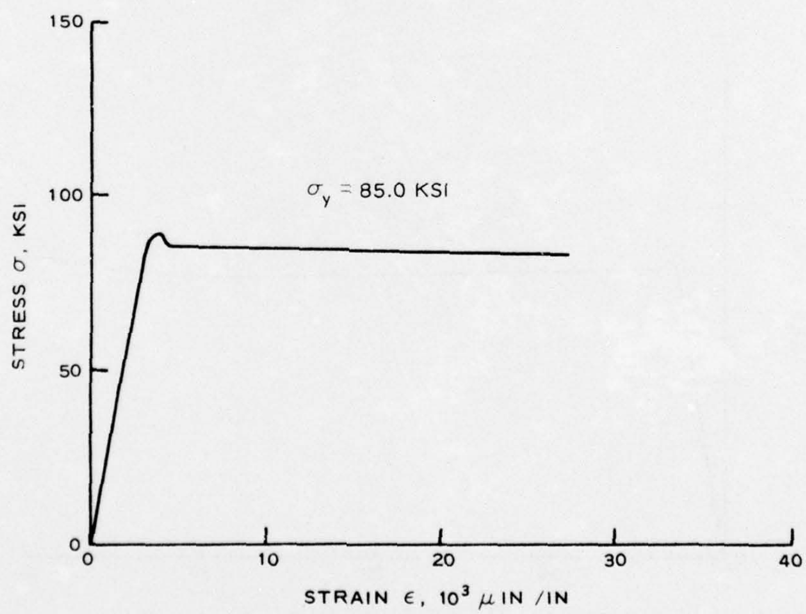


Figure 3.18 Stress versus strain, Test 232, angle splice.

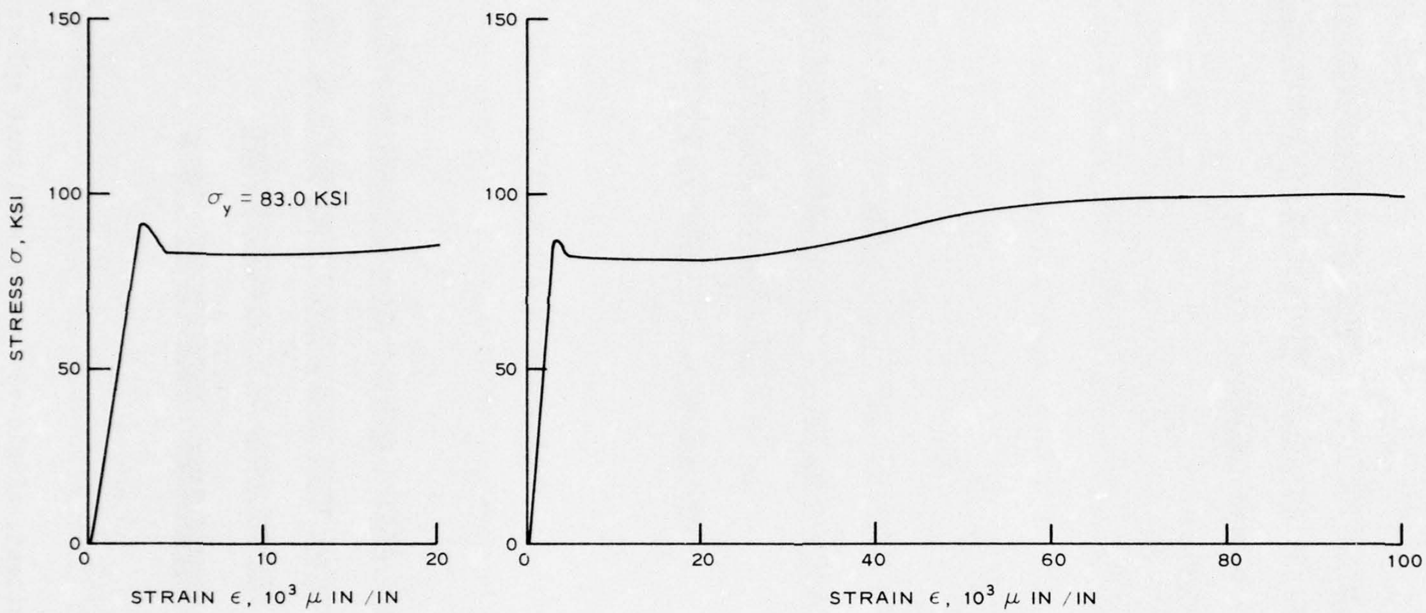


Figure 3.19 Stress versus strain, Test 233, angle splice.

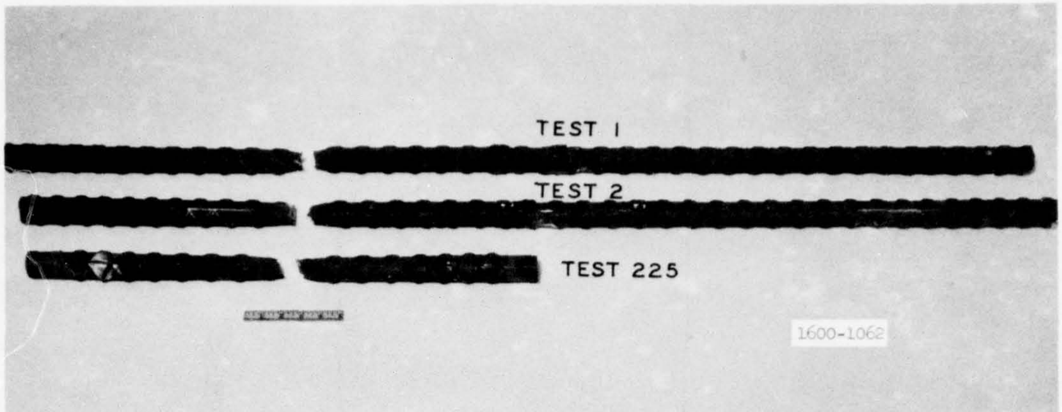


Figure 3.20 Posttest, as-rolled rebar samples.

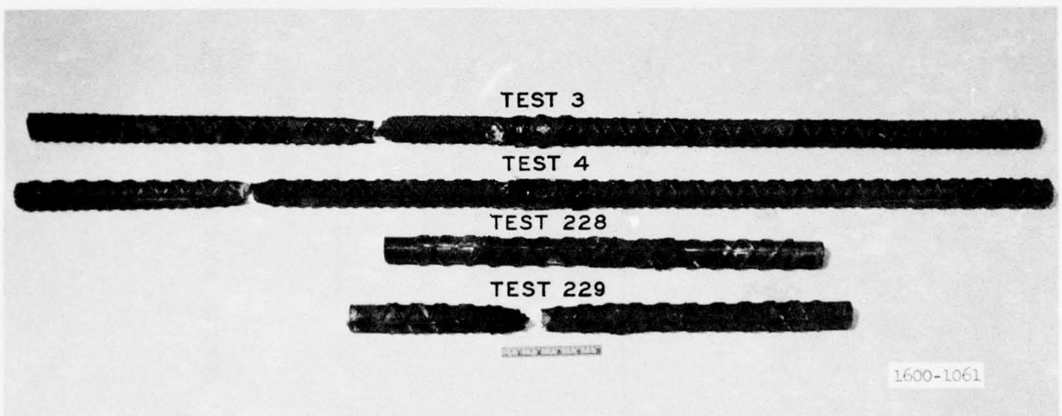


Figure 3.21 Posttest, double-vee groove weld butt splice samples.

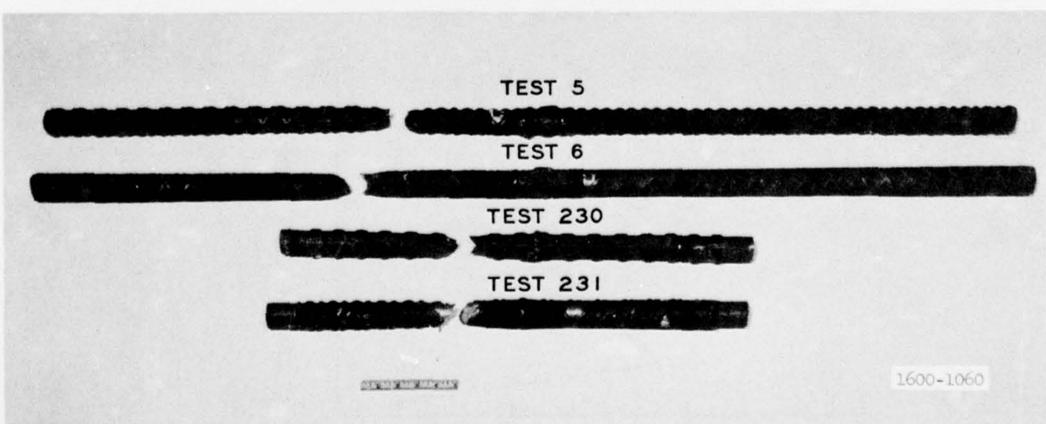


Figure 3.22 Posttest, single-vee groove weld butt splice samples.

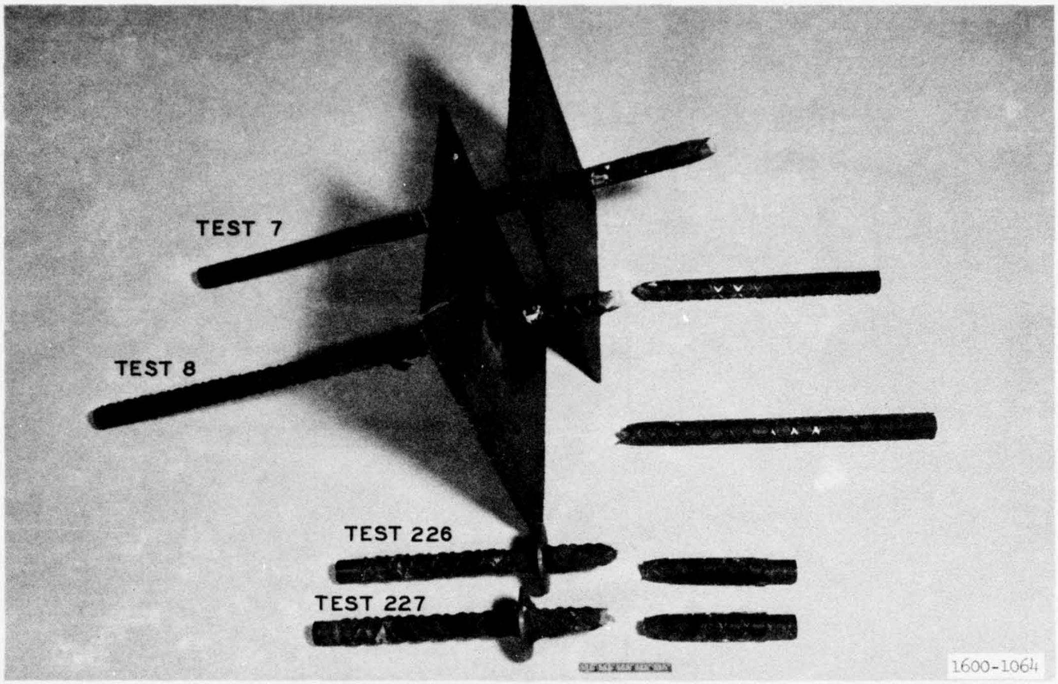


Figure 3.23 Posttest, plate penetration rebar samples.

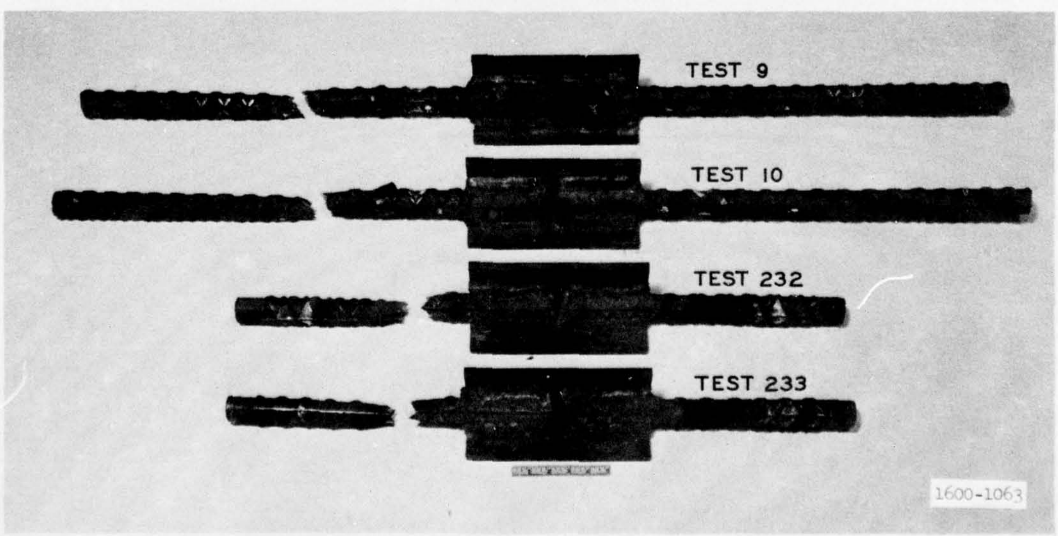


Figure 3.24 Posttest, angle splice rebar samples.

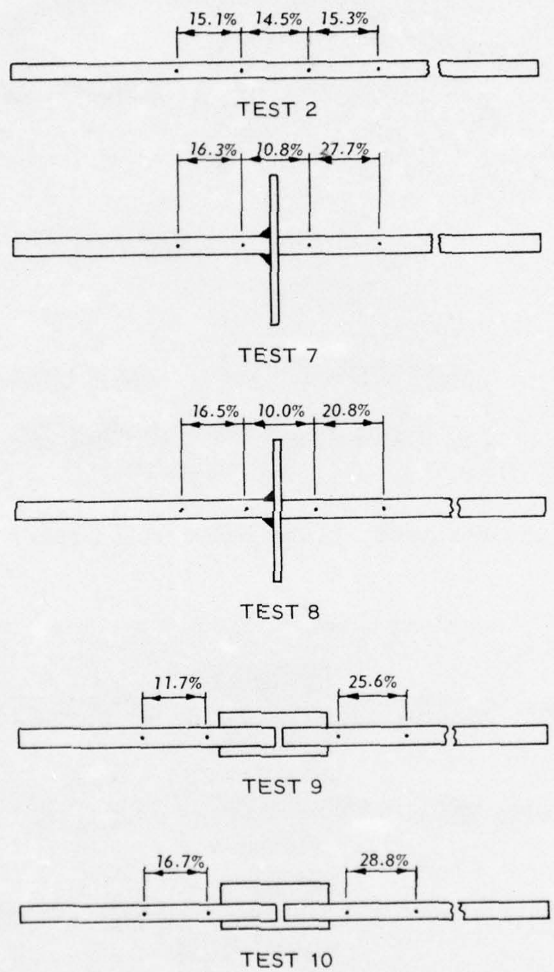


Figure 3.25 Comparison of elongation of statically tested samples.

Figure 3.26 Typical ductile type fracture of No. 11 rebar.

Figure 3.27 Posttest view of typical longitudinal flaw on No. 11 rebar.

CHAPTER 4

CONCLUSIONS

Based on the results of this study, the following conclusions are believed warranted: (1) The Ben-Weld steel will meet the strength requirement of ASTM A 615, Grade 60 steel reinforcement bars. (2) Splice welding or bracket welding does not seriously degrade the ductility of this type material. Final elongations in the 20 percent range can be expected after welding. (3) Preheating requirements are simplified. The practices recommended in Reference 5 call for preheat in the 200 to 400 F range for Grade 60 material.

REFERENCES

1. W. J. Flathau; "Dynamic Tests of Large Reinforcing Bar Splices"; Technical Report N-71-2, April 1971; U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.; Unclassified.

2. J. R. Hossley; "Bronze-Brazed Joints for Sealing Rebar Penetrations of Electromagnetic Pulse Shields"; Miscellaneous Paper N-72-7, June 1972; U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg Miss.; Unclassified.

3. American Society for Testing and Materials; "Standard Specifications for High-Strength Deformed Billet-Steel Bars for Concrete Reinforcement"; Designation: A 615-68, 1968 Book of ASTM Standards, Part 4, 1968, Philadelphia, Pa.; Pages 890-895; Unclassified.

4. American Welding Society; "Low-Alloy Steel Covered Arc-Welding Electrodes"; Designation: AWS A5.5-58; New York, N. Y.; Unclassified.

5. American Welding Society; "Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction"; Designation: AWS D12.1-61; New York, N. Y.; Unclassified.

6. American Society for Testing and Materials; "Standard Specifications for Structural Steel"; Designation: A 36-67, Book of ASTM Standards, Part 4, 1968, Philadelphia, Pa.; Pages 79-82; Unclassified.

7. American Society for Testing and Materials; "Standard Methods and Definitions for Mechanical Testing of Steel Products"; Designation: A 370-67, 1968 Book of ASTM Standards, Part 4, 1968, Philadelphia, Pa.; Pages 440-493; Unclassified.

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EVALUATION TESTS OF BEN-WELD NO. 11 REINFORCING STEEL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

James R. Hossley

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1973	40	7

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper N-73-5
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Engineer Division, Huntsville Huntsville, Alabama

13. ABSTRACT

The objective of this study was to determine the tensile properties at fast load rates of welded Ben-Weld No. 11 concrete reinforcing steel bars. Ben-Weld is a trade name of the U. S. Steel Corporation, Pittsburgh, Pennsylvania. Nineteen tension tests were conducted. Twelve samples were spliced using three different welding methods; i.e., direct single-vee groove weld, direct double-vee groove weld, and indirect angle splice. Four of the sample bars were passed through and welded to a 1/4-inch-thick steel plate to simulate the rebar penetrations of the electromagnetic pulse (EMP) shields used in the Perimeter Acquisition Radar Building (PARB) of the SAFEGUARD System. All samples were tested at static and dynamic (intermediate) loading rates. The time to reach yield at the intermediate loading rate was approximately 0.10 second. Transient load and strain measurements were recorded during the tests. The results of these tests showed that a welded Ben-Weld bar will exceed the minimum requirements for tensile and yield strengths for Grade 60 bars as stipulated by the American Society for Testing and Materials. The test results also indicated that welding does not seriously affect the ductility of the material and that final elongations of approximately 20 percent can be expected from welded rebars.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified
Security Classification

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Ben-Weld No. 11 reinforcing steel						
Reinforcing bars						
Reinforcing steels						
Tensile properties						
Welded bars						

Unclassified
Security Classification

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below:

Hossley, James R

Evaluation tests of Ben-Weld No. 11 reinforcing steel, by J. R. Hossley. Vicksburg, Miss., U. S. Army Engineer Waterways Experiment Station, 1973.

40 p. illus. 27 cm. (U. S. Waterways Experiment Station. Miscellaneous paper N-73-5)

Sponsored by U. S. Army Engineer Division, Huntsville.

References: p. 39.

1. Ben-Weld No. 11 reinforcing steel. 2. Reinforcing bars. 3. Reinforcing steels. 4. Tensile properties. 5. Welded bars. I. U. S. Army Engineer Division, Huntsville. (Series: U. S. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper N-73-5)

TA7.W34m no.N-73-5